

### **REMARKS/ARGUMENTS**

With respect to paragraph 3 of the Office action, the applicant “is asked to review the figures, the formulas, and other pertinent part[s] of the disclosure that appear to be incorrect, and provide appropriate corrections, or explain why the examiner is mistaken.” The explanation requested by the examiner is provided in response to the examiner’s request in paragraph 7 of the Office action for a detailed, step-by-step explanation of how to transpose the matrix of FIG. 15A into the matrix of either FIG. 15B or 15C. In response to that request, applicant provides a detailed explanation below which demonstrates that for an east-north shift, the counts are calculated using the equation  $(X+Y+1)\text{MOD}(\text{array size})$ . No changes to the specification are believed to be necessary.

In paragraph 6 of the Office action, claims 1-20 and 26 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. The examiner’s concerns are addressed by demonstrating the operability of the present invention in conjunction with FIG. 15, as requested by the examiner.

Appendix 1 filed herewith illustrates, in the upper left-hand corner, the original data matrix shown in FIG. 15A. Each of the processing elements (PEs) is given a number which appears in a circle. Thus, the top row of the matrix is comprised of PEs 1, 2, 3, and 4, which hold data a, b, c, and d, respectively. Similarly, the first column of the matrix is comprised of PEs 1, 5, 9, and 3, which hold data a, e, i, and m, respectively. This original data matrix is given a count of 0. The count of 0 indicates that the original data held by a PE is the data that the PE should present as output in the transposed matrix.

The data matrix appearing in the upper right corner is the data as it appears after the first pair of shift operations. That data matrix is given a count of 1. More particularly, the data matrix having a count of 1 is the matrix which results after all of the data in the data matrix having a count of 0 has been shifted one PE east and one PE north. Referring to Appendix 3, the data m in PE 13, after one east shift and one north shift, is now held by PE 10. Thus, at this point in the operation, PE 10 has “seen” data j, its original data, and data m.

Data that shifts “off the matrix” to the right wraps around the matrix to the far left column and then is shifted up one PE. For example, the data h held by PE 8 wraps around to

PE 5 and then is shifted north to PE 1 so that after the first pair of shift operations the data h held by PE 8 is now held by PE 1.

In a similar manner, data that shifts “off the top” of the matrix appears at the bottom of the same row. Thus, the data a held by PE 1 is shifted east to PE 2, then shifted north, via the wrap-around feature, to PE 14. In that manner, the data a held by PE 1 in the matrix of count 0, is held by the PE 14 in the matrix of count 1.

Returning to appendix 1, and turning now to the matrix in the middle left of appendix 1, that matrix illustrates the data after the second pair of shift operations. That matrix is given a count of two. We can see that the data m previously held in PE 10 is now held in PE 7. The data a previously held by PE 14, is now held by PE 11. The data h previously held by PE 1 in the matrix of count 1 is now held by PE 14 in the matrix of count 2.

Turning now to the matrix of count 3, the data m held by PE 7 in the matrix of count 2, is now held by PE 4 in the matrix of count 3. We can see that as a result of the three pair of shift operations, the data m has moved from PE 13 in the matrix of count 0, to PE 10 in the matrix of count 1, to PE 7 in the matrix of count 2, and finally to PE 4 in the matrix of count 3. Similarly, the diagonal (formed by virtue of a wrap-around operation) comprised of PEs 1, 14, 11, and 8 have all received the original data held by every other processing element in that diagonal. Applicant has thus demonstrated that each element in a diagonal of length N receives the original data held by every other element in that diagonal.

For purposes of completeness of the explanation, a fourth pair of shift operations has been performed as shown in Appendix 1 to demonstrate that after the fourth pair of shift operations the data returns to its original position; compare the matrix of count 0 to the matrix of count 4. In reality, it is not necessary to perform the fourth pair of shift operations as each PE is provided with sufficient memory so as to store its original data plus all the data that it has received as a result of the three pair of shift operations. Appendix 1 thus demonstrates how each diagonal of length N receives the original data held by every other element in that diagonal.

The examiner's next concern is with the equations used to derive the counts. For purposes of explanation, a matrix of counts has been prepared and appears in the upper left-hand corner of Appendix 2. This count matrix has been prepared by comparing the data in FIG. 15A with the data in FIG. 15B of the application. For example, PE 1 in FIG. 15A contains the data a.

In FIG. 15B, PE 1 also contains the data a. The data a which PE 1 originally holds is the data to be presented as the final output. Thus, the count for PE 1 is zero. For PE 2, the original data held in FIG. 15A is b. However, the output data as seen in FIG. 15B is e. We can see from the data matrix having count 1 in Appendix 1 that PE 2 has data e when the count is equal to 1 (i.e., after the first pair of shift operations). Thus, a 1 is placed in the count matrix appearing in the upper left-hand corner of FIG. 2 for PE 2.

Next, PE 3 originally holds data c as shown in FIG. 15A. However, in FIG. 15B, the output of PE 3 is to be the data i. We can see from Appendix 1 and the data matrix having a count of 2, that PE 3 receives the data i when the count is 2. Thus, we put a count of 2 in the count matrix appearing in the upper left-hand corner of Appendix 2.

Turning now to PE 4, we can see from FIG. 15A that the original data is d but FIG. 15B indicates that the output data is to be m. We can see from the data matrix having a count of 3 that PE 4 has the data m when the count is 3. A count of 3 is placed in the count matrix.

Continuing now with the second row of the matrix of FIG. 15A, we see that the PE 5 originally holds data e, but according to FIG. 15B, must output data b. PE 5 receives data b when the count is equal to 3. Thus, a 3 is put in the count matrix appearing in the upper left-hand corner of FIG. 2.

The next processing element in the second row is PE 6. PE 6 originally holds the data f and is to output the data f as its final output. Therefore, in the count matrix appearing in the upper left-hand corner of Appendix 2, we place a 0 as the count value for PE 6.

For PE 7, that PE originally holds data g as shown in FIG. 15A but is to output the data j as shown in FIG. 15B. We can see that PE 7 receives the data j when the count is equal to 1. Therefore, a 1 is placed in the count matrix in the upper left-hand corner of Appendix 2 for PE 7.

We see from FIG. 15A that PE 8 originally holds the data h, but in FIG. 15B PE 8 is to output the data n. We can see from the data matrix of count 2 that PE 8 receives the data n when the count is 2. Therefore, we put a 2 in the count matrix appearing in the upper left-hand corner of Appendix 2. The count matrix for the final two rows is prepared in a similar manner.

Turning now to the issue of the equation (See Appendix 2), the equation  $(X+Y+1)\text{MOD}(4)$  maybe used to calculate each of the count values. For example, for the first

column, for the four PEs 1, 5, 9, and 13, the value for X is zero, the value for Y is 3, 2, 1, 0, respectively, so that the equation reduces to:

$$4 \text{ MOD}(4)$$

$$3 \text{ MOD}(4)$$

$$2 \text{ MOD}(4)$$

$$1 \text{ MOD}(4) \text{ for PEs 1, 5, 9, and 13, respectively.}$$

For PE 1, 4 divided by 4 is 1 with a remainder of 0. For PE 5, 3 divided by 4 is 0 with a remainder of 3. For PE 9, 2 divided by 4 is zero with a remainder of 2. And for PE 13, 1 divided by 4 is zero with a remainder of 1. It is thus demonstrated that the equation  $(X+Y+1)\text{MOD}(\text{array size})$  provides the counts four PEs 1, 5, 9, and 13, respectively. In a similar manner, Appendix 2 demonstrates that the counts for all of the PEs can be arrived at using the equation  $(X+Y+1)\text{MOD}(\text{array size})$ .

It is respectfully submitted that the information provided in this amendment with respect to FIG. 15A and FIG. 15B is duplicative of information appearing in the application as filed. The information provided in this amendment has been provided at the request of the examiner to provide a more simple example than the example presented in the application which is an 8 by 8 matrix. More particularly, if FIGs. 17A-H are compared to the original input data of FIG. 16A, it is seen that the data is shifted along diagonals. For example, the original data of row 1 of FIG. 16A is presented in FIG. 17A. Thereafter, a first pair of shifts is performed which, in this example, is an east shift and a north shift of all of the data in the array. Examining row 2 of FIG. 16A, and comparing that to FIG. 17B, it is seen that the first row of processing elements (FIG. 17B) now has data from the second row of processing elements (FIG. 16A), but shifted to the east by one processing element, and taking into account the wrap function. Thereafter, the process is repeated, i.e., pairs of east and north shifts are performed.

Looking again at FIGs. 17A-17H, and focusing on the eighth or last processing element in the row, it is seen that that processing element originally contains h1, and then receives in sequence g2, f3, e4, d5, c6, b7, and a8. Now, if one looks at the original input data, it is seen that that data received by the last processing element of the first row as a result of seven pairs of east/north shifts is all the data in the diagonal of which the last processing element is a part. The same is true for every processing element in the array. Thus, it is respectfully submitted that

FIG. 16A, viewed in combination with FIGs. 17A-17H, clearly demonstrates the feature of shifting data along diagonals of the processing elements until each processing element in the diagonal has received the data held by every other processing element in that diagonal.

The examiner's attention is also directed to paragraph [0071] which discusses FIG. 16A and 17A-17H, which is reproduced here for the examiner's convenience.

**[0071]** Turning to FIGs. 16A and 16B, FIG. 16B represents one possible transpose of the data of FIG. 16A. FIG. 17A illustrates the data appearing in the first row of the matrix of FIG. 16A while FIGs. 17B through 17H illustrate the data as it appears as a result of seven consecutive horizontal/vertical pairs of shifts, i.e., move data right (east) 1 PE, and move data up (north) one PE. In FIG. 17A, the data "a1" appearing in position one represents that data in the first row of the transpose of FIG. 16B. So that data is selected as the final output. In FIG. 17B, after the first pair of east/north shifts, the data "a2" appearing in position two represents the data in the first row of the transpose of FIG. 16B. Similarly, in FIGs. 17C through 17H the data "a3" to "a8" appears in positions three through eight, respectively. Using the expression  $(X+Y+1) \text{ MOD } (8)$ , the local counters in each of the processing elements may be set to an initial count as illustrated in FIG. 18.

It is readily apparent that if data is moved to the right one PE and up one PE, in a series of consecutive horizontal/vertical pairs of shifts, that the data will be shifted along a diagonal.

Furthermore, FIG. 18 illustrates the count in each of the processing elements which enables that processing element to select, from amongst all of the data which it receives, the appropriate data to output so as to affect a transpose of the data. Examining the top row in FIG. 18, it is seen that the first processing element has a count of zero, corresponding to FIG. 17A, which indicates that the original data in that processing element is the data which that processing element should output to effect a transpose of the data in the array. That count is arrived at using the equation  $(X+Y+1)\text{Mod}(8)$  which is equal to  $(0+7+1)\text{Mod}(8)=0$ . Similarly, the eighth processing element in the first row has a count of seven, indicating that that processing element must wait for seven shifts, see FIG. 17B-17H, until it receives the data a8. The count of seven thus enables the eighth processing element in the first row to select as its output the data it receives after the seven pairs of shifts. The count is arrived at using the equation  $(7+7+1)\text{Mod}(8)$ . 15 divided by 8 is equal to 1 with a remainder of 7. It is respectfully submitted that paragraph [0071], FIG. 16A and FIGs. 17A-17H demonstrate how every element in a given

diagonal can receive data held by every other element in that diagonal. FIG. 18 clearly illustrates how each of the processing elements selects from amongst all of the data which it has received, that data which is to be output to effect a transpose of the input data. Finally, FIGs. 19A-19L reiterate the foregoing by illustrating input data, output data, and counter values through the process of shifting data. See paragraphs [0072] – [0075].

Applicant has made a *bona fide* effort to address the examiner's concern and to provide the detail example requested by the examiner. Should the examiner have any remaining questions, the examiner is invited to contact the undersigned to address any remaining concerns. A Notice of Allowance for pending claims 1-20 and 26 is respectfully requested.

Respectfully submitted,



Edward L. Pencoske  
Reg. No. 29,688  
JONES DAY  
One Mellon Center  
500 Grant Street, Suite 3100  
Pittsburgh, PA, USA, 15219  
(412) 394-9531  
(412) 394-7959 (Fax)  
Attorneys for Applicant

Original  
Data  
Matrix  
See Fig  
15A

① a	② b	③ c	④ d
⑤ e	⑥ f	⑦ g	⑧ h
⑨ i	⑩ j	⑪ k	⑫ l
⑬ m	⑭ n	⑮ p	⑯ q

count = 0

Data  
Matrix  
After 1st  
Pair of  
Shift  
operations

① h	② e	③ f	④ g
⑤ l	⑥ i	⑦ j	⑧ k
⑨ q	⑩ m	⑪ n	⑫ p
⑬ d	⑭ a	⑮ b	⑯ c

count = 1

Data  
Matrix  
After 2nd  
Pair of  
Shift  
operations

① k	② l	③ i	④ j
⑤ p	⑥ q	⑦ m	⑧ n
⑨ c	⑩ d	⑪ a	⑫ b
⑬ g	⑭ h	⑮ e	⑯ f

count = 2

Data  
Matrix  
After 3rd  
Pair of  
Shift  
operations

① n	② p	③ q	④ m
⑤ b	⑥ c	⑦ d	⑧ a
⑨ f	⑩ g	⑪ h	⑫ e
⑬ j	⑭ k	⑮ l	⑯ i

count = 3

① a	② b	③ c	④ d
⑤ e	⑥ f	⑦ g	⑧ h
⑨ i	⑩ j	⑪ k	⑫ l
⑬ m	⑭ n	⑮ p	⑯ q

count = 4

A fourth pair of  
Shift operations returns  
the data to its  
original position

①	②	③	④
0	1	2	3
⑤	⑥	⑦	⑧
3	0	1	2
⑨	⑩	⑪	⑫
2	3	0	1
⑬	⑭	⑮	⑯
1	2	3	0

Local  
Counts used  
by PEs to  
Select  
Value

PE number →

Use equation  
 $(x+y+1) \text{Mod}(4)$  To  
Calculate local PE counts

$$\begin{aligned} \textcircled{4} & 3 + 3 + 1 = 7 \text{Mod}(4) = 3 \\ \textcircled{8} & 3 + 2 + 1 = 6 \text{Mod}(4) = 2 \\ \textcircled{12} & 3 + 1 + 1 = 5 \text{Mod}(4) = 1 \\ \textcircled{16} & 3 + 0 + 1 = 4 \text{Mod}(4) = 0 \end{aligned}$$

$$\textcircled{3} 2 + 3 + 1 = 6 \text{Mod}(4) = 2$$

$$\textcircled{7} 2 + 2 + 1 = 5 \text{Mod}(4) = 1$$

$$\textcircled{11} 2 + 1 + 1 = 4 \text{Mod}(4) = 0$$

$$\textcircled{15} 2 + 0 + 1 = 3 \text{Mod}(4) = 3$$

$$\textcircled{6} 1 + 3 + 1 = 5 \text{Mod}(4) = 1$$

$$\textcircled{10} 1 + 2 + 1 = 4 \text{Mod}(4) = 0$$

$$\textcircled{14} 1 + 1 + 1 = 3 \text{Mod}(4) = 3$$

$$\textcircled{18} 1 + 0 + 1 = 2 \text{Mod}(4) = 2$$

$$\textcircled{1} 0 + 3 + 1 = 4 \text{Mod}(4) = 0$$

$$\textcircled{5} 0 + 2 + 1 = 3 \text{Mod}(4) = 3$$

$$\textcircled{9} 0 + 1 + 1 = 2 \text{Mod}(4) = 2$$

$$\textcircled{13} 0 + 0 + 1 = 1 \text{Mod}(4) = 1$$



①	②	③	④
a →			
⑤	⑥	⑦	⑧
			h
⑨	⑩	⑪	⑫
⑬	⑭	⑮	⑯
m →			

original  
data matrix of  
Fig. 15a indicating an upcoming  
east shift      count = 0

①	②	③	④
↑ a			
⑤	⑥	⑦	⑧
h			
⑨	⑩	⑪	⑫
⑬	⑭	⑮	⑯
	↑ m		

Data after east shift  
and indicating an upcoming  
north shift.

①	②	③	④
h			
⑤	⑥	⑦	⑧
⑨	⑩	⑪	⑫
	m		
⑬	⑭	⑮	⑯
	a		

Data after north (2nd)  
shift  
count = 1